Lat 38.877 Lon -119.987

Forest Health Protection

Pacific Southwest Region
Northeastern California Shared Service Area

Date: November 30, 2018
File Code: 3420

To: Forest Supervisor, Lake Tahoe Basin Management Unit

Subject: Insect and disease considerations for Stand 1197 (FHP Report NE18-12)

On October 9, Danny Cluck, Forest Health Protection (FHP) entomologist, and Bill Woodruff, FHP plant pathologist, visited Stand 1197 within the Lake Tahoe Basin Management Unit for which Paul Guarnaccia is writing the silvicultural prescription. In addition to documenting silvicultural recommendations, the prescription will satisfy one of the requirements needed for Paul's silvicultural certification in Region 5.

Stand 1197 is a Jeffrey pine-dominated stand adjacent to two California spotted owl protected activity centers (PACs), a designated roadless area and boarded on the north by an electrical power corridor. The stand is near the southern edge of the city of South Lake Tahoe at Latitude 38.877N and Longitude 119.987W and is heavily used for recreation such as mountain biking. Forests in this area mostly regenerated after the clearcutting that occurred 130 to 140 years ago around Lake Tahoe. Management objectives for the stand include fire protection, growing large old trees and enhancing and maintaining forest health.

A recent stand exam reported that Stand 1197 was mostly Jeffrey pine (96 trees per acre and 247 sq.ft. BA) with lesser amounts of white fir (30 tpa and 12.1 sq.ft. BA), lodgepole pine (12 tpa and 9 sq.ft. BA) and incense cedar (1.4 tpa and 4.3 sq.ft BA). The exam indicated that the average dwarf mistletoe rating (DMR) was 2.4 for Jeffrey pine infected with the parasite *Arceuthobium campylopodum* (Figure 1). Past management in the stand includes hand cutting and piling of understory trees less than 10" dbh in the 1990s with subsequent pile burning.

Figure 1. Jeffrey pine heavily infected with dwarf mistletoe

The white fir and lodgepole pine are mostly grouped by species in several areas within the stand. As a result of the drought of 1987-1992 many white fir were killed by fir engraver beetle (*Scolytus ventralis*) (Figure 2a and 2b) as well as many lodgepole pine killed by mountain pine beetle (*Dendroctonus ponderosa*) (Figure 3). There were also dense pockets of Jeffrey pine that were killed by Jeffrey pine beetle (*Dendroctonus jeffreyi*). These dead trees are now on the ground contributing to heavy fuel loading in some locations. Some of the white fir that died may have

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Figure 2a and 2b. Dead and down white fir likely resulting from the drought of 1987-1992.

Figure 3. Dead and down lodgepole pine likely resulting from the drought of 1987-1992

been predisposed to bark beetle attack by Heterobasidion root disease (*H. occidentale*), a disease common to white fir stands in California. Symptoms consistent with infection by *H. occidentale* were found throughout the stand. A decayed root of a lodgepole pine was symptomatic of *H. irregulare* decay but the fungus could not be confirmed in the lab.

The high number of dead trees in this stand is an example of the type of mortality that can occur during drought in overstocked stands. If warmer and drier climate predictions are realized, managing stocking levels and species composition will be critical to maintaining a healthy forest on this dry pine site. Thinning the stand to between 60 and 100 square foot basal area and maintaining this basal area into the future should make trees more resilient and better able to survive future droughts. Stand exam data shows that Jeffrey pine is currently growing at or above twice the recommended stocking levels (Figure 4).

The latest peer-reviewed research on Jeffrey pine stocking as it relates to Jeffrey pine beetle-caused mortality (Egan et al 2016) and a FHP report for the same study (Egan et al 2009) suggest stocking levels that are at or below SDI 210 (corresponded to < 125 sq.ft./acre of basal area in study plots) to reduce tree mortality during droughts and high bark beetle population pressure. Stocking levels of SDI 110 (corresponded to <80 sq.ft./acre of basal area in study plots) had no Jeffrey pine beetle-caused mortality during the Jeffrey pine beetle outbreak monitored during the study.

Figure 4. Overstocked Jeffrey pine in Stand 1197.

When thinning Stand 1197, Jeffrey pine should generally be retained over lodgepole pine and white fir should be reduced as much as possible, especially ones that show symptoms of root disease infection, since white fir is not suited to this site based on precipitation (Figure 5). All of the project area receives less than 30 inches of annual precipitation. Thirty inches is below what is generally required for healthy white fir forests to exist over the long-term. Therefore, even at the lowest stocking levels, white fir growing on these sites are at a high to extreme risk for fir engraver beetle-caused mortality during periods of drought. The limited amount of incense cedar within the stand, a species generally resistant to pests and pathogens, could be retained to maintain some species diversity. Trees with healthy full crowns should be retained over diseased trees or trees with poor crowns. Openings could be created within lodgepole pine pockets to regenerate Jeffery pine.

In addition to high tree densities resulting in beetle-caused mortality, dwarf mistletoe is a serious health issue for the Jeffrey pine trees in Stand 1197. This parasite can weaken an infected pine tree with a DMR 3 or greater; predisposing it to successful bark beetle attack. A pine tree with a DMR 5 or greater can be killed by the parasite when stressed by drought. Heavily dwarf mistletoe-infected Jeffrey pine trees should be removed and only vigorously-growing trees with infections in the lower third of their crowns retained when needed for

stocking. Dwarf mistletoe plants in overstory branches always threaten understory pine regeneration. Wherever possible, dwarf mistletoe-infected Jeffery pine should be removed from around openings to protect future Jeffrey or ponderosa pine seedlings (if planted) in the openings from becoming infected when dwarf mistletoe seed are released each year.

All stumps greater than 14" diameter should be treated with a registered borate fungicide to prevent Heterobasidion root disease from becoming established in the roots of cut trees. Cellu-Treat produced by Nisus Corp. is the only commercially available fungicide registered in California for treating stumps to prevent Heterobasidion root disease. SPORAX is still registered for treating stumps and existing stocks may be used, but it is no longer commercially available. If you have any questions regarding this report and/or need additional information please contact Bill Woodruff or Danny Cluck.

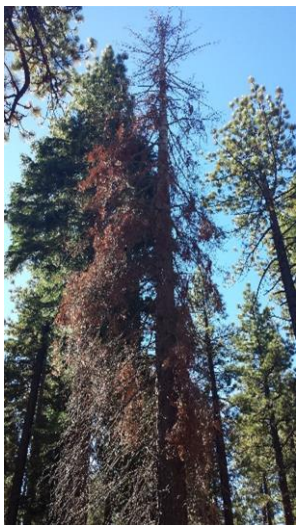

Figure 5. Recent white fir mortality.

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References:

Egan JM, Fournier D, Safford H, Sloughter JM, Cardoso T, Trainor P, Wenz J (2011) Assessment of a Jeffrey pine beetle outbreak from 1991–1996 near Spooner Junction, Lake Tahoe Basin. U.S. Department of Agriculture, Forest Service, Forest Health Protection, Sonora

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Pest Biologies:

Western Dwarf Mistletoe

Dwarf mistletoes (Arceuthobium spp.) are parasitic, flowering plants that can only survive on living conifers in the Pinaceae. They obtain most of their nutrients and all of their water and minerals from their hosts. Western dwarf mistletoe (A. campylopodum) infects principally ponderosa, Jeffrey, and knobcone pines, and occasionally Coulter and lodgepole pines.

Evidence of mistletoe infection includes the presence of aerial shoots, swollen branches, and witches' broom. Aerial shoots produce seeds which are forcibly discharged in the fall. These seeds have a sticky coating which allows them to adhere to surfaces they contact. Seeds that land on needles and twigs of a host will overwinter there and germinate the following spring. The radicle of the seed penetrates the bark of 1-yr-old twigs and develops an endophytic system in the inner bark and sapwood. In two to four years, this infection produces new aerial shoots which flower and produce seed in another two to four years.

The spread of dwarf mistletoe is limited to the distance travelled by the seed, which from overstory to understory is usually 20-60 feet; wind may carry the seeds as far as 100 feet from their source. A rule of thumb is that dwarf mistletoes can spread a horizontal distance equal to the height of the plants in the infected tree as long as the seeds are not intercepted. The actual spread rate through an even-aged, single species stand is one to two feet per year. Vertical spread in a tree crown is about 4 inches per year.

Western dwarf mistletoe is a major cause of mortality, growth loss, and reduced vigor of ponderosa and Jeffrey pine. Past statewide surveys indicate that during drought years, dwarf mistletoes as a group are involved in about 40% of the conifer mortality. During years of normal precipitation, this proportion drops to about 20%. Dwarf mistletoes also cause significant declines in tree growth and stand productivity. The amount of growth reduction depends on the incidence and severity of infection, and on site quality. Methods for determining the growth loss occurring in a specific stand have not been developed, but a rough estimate for lightly infected stands on an average site is 10 cu ft/ac/yr. This is 6-8% of the mean annual increment. Stands with heavier mistletoe infections would have greater impacts on growth.

Heterobasidion root disease

Heterobasidion spp. is a fungus that attacks a wide variety of woody plants. All western conifer species are susceptible. Madrone (*Arbutus menziesii*), and a few brush species (*Arctostaphylos spp.* and *Artemisia tridentata*) are occasional hosts. Other hardwood species are apparently not infected. The disease has been reported on all National Forests in California, with incidence particularly high on true fir in northern California, in the eastside pine type forests, and in southern California recreation areas.

Heterobasidion root disease is one of the most important conifer diseases in Region 5. Current estimates are that the disease infests about 2 million acres of commercial forestland in California, resulting in an annual volume loss of 19 million cubic feet. Other potential impacts of the disease include: increased susceptibility of infected trees to attack by bark beetles, mortality of infected trees presently on the site, the loss of the site for future production, and depletion of vegetative cover and increased probability of tree failure and hazard in recreation areas.

During periods favorable to the fungus, fruiting bodies (conks) form in decayed stumps, under the bark of dead trees, or under the duff at the root collar. New infection centers are initiated when airborne spores produced by the conks land and grow on freshly cut stump surfaces. Infection in true fir may also occur through fire and mechanical wounds, or occasionally, through roots of stumps in the absence of surface colonization. From the infected stump surface, the fungus grows down into the roots and then spreads via root-to-root contact to adjacent live trees, resulting in the formation of large disease centers. These infection centers may continue to enlarge until they reach barriers, such as openings in the stand or groups of resistant plants. In pines, the fungus grows through root cambial tissue to the root crown where it girdles and kills the tree. In true fir and other non-resinous species, the fungus sometimes kills trees, but more frequently is confined to the heartwood and inner sapwood of the larger roots. It then eventually extends into the heartwood of the lower trunk and causes chronic decay and growth loss.

Heterobasidion root disease in western North America is caused by two species:
Heterobasidion occidentale (also called the 'S' type) and *H. irregulare* (also called the 'P' type). These two species of *Heterobasidion* have major differences in host specificity. *H. irregulare* ('P' type) is pathogenic on ponderosa pine, Jeffrey pine, sugar pine, Coulter pine, incense cedar, western juniper, pinyon, and manzanita. *H. occidentale* ('S' type) is pathogenic on true fir, spruce and giant sequoia. This host specificity is not apparent in isolates from stumps; with *H. occidentale* being recovered from both pine and true fir stumps. These data suggest that infection of host trees is specific, but saprophytic colonization of stumps is not. The fungus may survive in infected roots or stumps for many years. Young conifers established near these stumps often die shortly after their roots contact infected roots in the soil.

Freshly cut stumps can be treated with a registered borate fungicide to prevent Heterobasidion root disease from becoming established in the roots of cut trees. Cellu-Treat produced by Nisus Corp. is the only fungicide registered in California for treating stumps to prevent Heterobasidion root disease.

Fir Engraver

The fir engraver attacks red and white fir in California. Fir engraver adults and developing broods kill true firs by mining the cambium, phloem, and outer sapwood of the bole, thereby girdling the tree. Trees greater that 4" in diameter are attacked and often killed in a single season. Many trees, weakened through successive attacks, die slowly over a period of years. Others may survive attack as evidenced by old spike-topped fir and trees with individual branch mortality. Although many other species of bark beetles cannot develop successful broods without killing the tree, the fir engraver beetle is able to attack and establish broods when only a portion of the cambium area has been killed.

Evidence of Attack

Fir engravers bore entrance holes along the main stem, usually in areas that are > 4" in diameter. Reddish-brown or white boring dust may be seen along the trunk in bark crevices and in spider webs. Some pitch streamers may be indicative of fir engraver attacks; however, true firs are known to stream pitch for various reasons and there is not clear evidence that pitch streamers indicate subsequent tree mortality or successful attack. Resin canals and pockets in the cortex of the bark are part of the trees defense mechanism. Beetle galleries that contact these structures almost always fail to produce larval galleries as the adults invariably abandon the attack. Pitch tubes, often formed when bark beetles attack pine, are not produced on firs.

Adults excavate horizontal galleries that engrave the sapwood; the larval galleries extend at right angles along the grain. Attacks in the crown may girdle branches resulting in individual branch mortality or "flagging". Numerous attacks over part or the entire bole may kill the upper portion of the crown or the entire tree. A healthy tree can recover if sufficient areas of cambium remain and top-killed trees can produce new leaders. The fir engraver is frequently associated with the roundheaded fir borer and the fir flatheaded borer.

Life Stages and Development

In the summer, adults emerge and attack new host trees. The female enters the tree first followed by the male. Eggs are laid in niches on either side of the gallery. Adult beetles carry the brown staining fungi, *Trichosporium symbioticum*, into the tree that causes a yellowish-brown discoloration around the gallery. The larvae mine straight up and down, perpendicular to the egg gallery. Winter is commonly spent in the larval stage, with pupation occurring in early spring. In most locations, the fir engraver completes its life cycle in 1 year, however at higher elevations 2 years may be required.

Conditions Affecting Outbreaks

Fir engravers bore into any member of the host species on which they land but establish successful galleries only in those that have little or no resistance to attack. Populations of less aggressive species like fir engraver are likely to wax and wane in direct relationship to the stresses of their hosts. Drought conditions often result in widespread fir mortality; however, attempting to determine when outbreaks will occur is difficult. Lowered resistance of trees appears to be a contributing factor. Overstocking and the increased presence of fir on sites that were once occupied by pine species may also contribute to higher than normal levels of fir mortality. Several insect predators, parasites and woodpeckers are commonly associated with the fir engraver and may help in control of populations at endemic levels.

Mountain pine beetle

The mountain pine beetle, *Dendroctonus ponderosae,* attacks the bole of ponderosa, lodgepole, sugar and western white pines larger than about 8 inches dbh. Extensive infestations have occurred in mature lodgepole pine forests. Group killing often occurs in mature forests and young overstocked stands of ponderosa, sugar and western white pines.

Evidence of Attack

The first sign of beetle-caused mortality is generally discolored foliage. The mountain pine beetle begins attacking most pine species on the lower 15 feet of the bole. Examination of infested trees usually reveals the presence of pitch tubes. Pitch tubes on successfully infested trees are pink to dark red masses of resin mixed with boring dust. Creamy, white pitch tubes indicate that the tree was able to "pitch out" the beetle and the attack was not successful. In addition to pitch tubes, successfully infested trees will have dry boring dust in the bark crevices and around the base of the tree. Attacking beetles carry the spores of blue-staining fungi which develop and spread throughout the sapwood interrupting the flow of water to the crown. The fungi also reduces the flow of pitch in the tree, thus aiding the beetles in overcoming the tree. The combined action of both beetles and fungi causes the needles to discolor and the tree to die.

Life Stages and Development

The beetle develops through four stages: egg, larva, pupa and adult. The life cycle of the mountain pine beetle varies considerably over its range. One generation per year is typical, with attacks occurring from late June through August. Two generations per year may develop in low elevation sugar pine. Females making their first attacks release aggregating pheromones. These pheromones attract males and other females until a mass attack overcomes the tree. The adults bore long, vertical, egg galleries and lay eggs in niches along the sides of the gallery. The larvae feed in mines perpendicular to the main gallery and construct small pupal cells at the end of these mines where they pupate and transform into adults.

Conditions Affecting Outbreaks

The food supply regulates populations of the beetle. In lodgepole pine, it appears that the beetles select larger trees with thick phloem, however the relationship between beetle populations and phloem thickness in other hosts has not been established. A copious pitch flow from the pines can prevent successful attack. The number of beetles, the characteristics of the tree, and the weather affect the tree's ability to produce enough resin to resist attack. Other factors affecting the abundance of the mountain pine beetle include nematodes, woodpeckers, and predaceous and parasitic insects. As stand susceptibility to the beetle increases because of age, overstocking, diseases or drought, the effectiveness of natural control decreases and pine mortality increases.

Jeffrey pine beetle

The Jeffrey pine beetle is the principle bark beetle found attacking Jeffrey pine, which is its only host. It is a native insect occurring from southwestern Oregon southward through California and western Nevada to northern Mexico. The beetle normally breeds in slow-growing, stressed trees. The beetles prefer trees which are large, mature, and occur singly rather than in groups. Yet when an epidemic occurs, the beetle may attack and kill groups of trees greater than 8 inches in diameter, regardless of age or vigor. Often the beetle infests lightning-struck or wind-thrown trees, but does not breed in slash.

Evidence of Attack

Presence of the beetle is usually detected when the foliage changes color. The color change of the foliage is related to the destruction of the cambium layer by the beetle. Generally, the top of the crown begins to fade in a slow sequence, with the needles turning from greenish yellow, to sorrel, and finally to reddish brown. By the time the tree is reddish brown, the beetles have usually abandoned the tree. Another sign of beetle attack is large, reddish pitch tubes projecting from the bark of the infested tree. If examined carefully, pitch tubes can be detected on infested green trees prior to crown fade. Jeffrey pine beetles have a distinctive "J" shape egg gallery pattern on the inner bark. Larval mines extend across the grain and end in open, oval-shaped pupal cells.

Life Stages and Development

The Jeffrey pine beetle is one of the larger pine bark beetles in California. The beetle has a 4 life stages, egg, larva, pupa, and adult. The adults are stout, cylindrical, black, and approximately five-sixteenths of an inch long when mature. The egg is oval and pearly-white. The larva is white, legless, and has a yellow head. The pupa is also white but is slightly smaller than the mature larva. The life cycle is normally completed in one year in the northern part of the range, but in the southern part, two generations per year may occur. The principle period of attack is in June and July, but attacks also are frequent in late September and early October. Similar to other *Dendroctonus* species, Jeffrey pine beetles use pheromones that attract other beetles to a tree, causing a mass attack that tends to overcome the tree's natural resistance. Blue stain fungi are associated with Jeffrey pine beetle attacks and aid in overcoming the tree’s defenses.

Conditions Affecting Outbreaks

Normally the Jeffrey pine beetle is kept in check by its natural enemies, climatic factors and the resistance of its host. Similar to other *Dendroctonus* species, the availability of suitable host material is a key factor influencing outbreaks. Healthy trees ordinarily produce abundant amounts of resin, which pitches out attacking beetles. When deprived of moisture, or stressed by other factors such as disease or fire injury, trees cannot produce sufficient resin flow and become susceptible to successful beetle attacks